FALL 2021

VOL.2

PMP
PRISON MATHEMATICS PROJECT

The Prison Mathematics Project NEWSLETTER

IN THIS ISSUE

Welcome to Issue #2 of the Prison Mathematics Project newsletter! We celebrate inclusivity and diversity in the math community by reaching lovers of mathematics, both incarcerated and unincarcerated. Our writers, editors and contributors have designed this newsletter for the sole purpose of sharing with you, the reader, our deep appreciation for the wonderful world that can be discovered through the study and exploration of mathematics. The aim of the Prison Mathematics Project is to create the desire for desistance from crime through the transformative experiences that can be discovered by making a life around a passion for mathematics.

ASK THE MATH GURU

by VaneSSa Vakharia

Do numbers freak you out? Does math send you into meltdown-mode? Are you wondering why we need to learn this stuff ANYways?! Don't worry, The Math Guru is here to help you work through your math trauma, one problem at a time. Ask for advice, guidance, or just a good ol' pep talk! *You got this!*

VaneSSa Vakharia, The Math Guru

Today's question comes from Ruth Utnage.

Dear Math Guru,
I am an incarcerated trans woman, and in 4 months I release after 10 ½ years of incarceration. I love math when I understand it. The problem is, I don't understand much of it, so I only love a little bit of math. I want to change that.
I have dreams of higher education. I want my PhD. Not many trans folx have that – not to mention trans folx with a record. I love sociology, I love business, and I need higher mathematics to pursue either one academically.
Here's where I think my problem is:
If you put me in a classroom setting, I excel, but self-study is a challenge for me when I don't have a curriculum to abide by. But only in math. I've already published academically in the field of criminology, passing a double-blind peer-review process. But if you ask me to prove 1+1=2, I'm lost.
My question is two-fold:
1) Is there a book that begins with Algebra 1 that can be used to create a self-study regimen?
2) How can I continue upon release using technology? Is there a recommended online math study guide?

have a ton of fun studying linear algebra and I love love love matrices. It's just that I don't have a complete grasp of basic algebra.

Where should a Math
Lame like me begin?

Sincerely,
Ruth Utnage

Ruth!
First of all, thank you so much for having the courage to not only reach out - but for having the goal of pursuing your PhD in Sociology or Business in the first place! I have some good news, and some even better news: the good news is that SO many people struggle with having a study regimen and with finding structure in their studies - you are not alone! The even BETTER news is that while you need some math to pursue the PhD programs you want, you're actually much farther along than you think. Neither of these fields are math-heavy!
My advice is twofold: first, I want you to look into the programs that you're interested in and actually find out what exactly the math requirements are. Second, once you've narrowed down the program requirements, you can come up with a plan of action! There are great free online resources, like Khan Academy, that teach you math lessons sequentially and even assign homework! The first step is to find out WHERE exactly you want to go, so that you can figure out HOW To get there. You're on the right track and Ruth, you are a role model to us all - thank you for stepping out of your comfort zone and following your dreams, even if it does seem like the path less chosen by so many (for now)!

Got math anxiety? Think you're a hopeless case? VaneSSa to the rescue! Contact her by email at vanessa@themathguru.ca, or write her a letter care of the Prison Mathematics Project, 10810 N. Tatum Blvd Ste 102-998, Phoenix, AZ 85028.

PARTICIPANT SPOTLIGHT

by Claire Finlayson

Well, someone has to keep these math geeks in line and jump on every little spelling mistake... I'm a writer from BC, Canada, so don't try to bust me for using British spelling, like "cheque" and "colour," okay? Although my math skills are rudimentary, I am a huge fan of the PMP and I have found a way to help. It's mostly the people involved in the project that interest me, so I write profiles of participants and volunteers.
If there's someone you'd like me to spotlight, here's how you can contact me:

www.clairefinlayson.com

claire@finlaysons.ca

Prison Mathematics Project,
10810 N. Tatum Blvd Ste 102-998
Phoenix, AZ 85028

CF: Everyone, I'd like to introduce you to Luke Hollinda, all around overachiever and one of our first volunteer mentors with the PMP.

Luke, I know you as a mentor to Marshall Byers, a former inmate who became a free man in June of this year. As you know, Marshall was the subject of our first Participant Spotlight in Issue #1, so I thought it would be great if we could chat with you next to get your perspective on the mentorship. First, tell us a bit about yourself. How old are you? What are your future plans, and what do you do for fun?

LH: I am 21 years old. My plans for the future mostly revolve around building a career in software engineering. I have my fingers crossed that a large tech company will pick me up and I have tentative plans to move to the US after I graduate. In my free time, I listen to an unhealthy number of podcasts, play a lot of piano, and spend time with friends and family.

CF: Can you tell me a bit about how you and Marshall "chose" each other, and how you were able to develop a relationship? I know it's cumbersome, with incarcerated people having no access to the internet. How on earth did you guys get anywhere?

LH: Last November a friend sent me a CBC article on the PMP project and I quickly reached out to see if I could help. When I first joined I was sent introductory letters from two inmates and asked to choose which one I would like to mentor. Marshall's letter really resonated with me because of his interest in set theory. You could tell that he was drawn to mathematics because of its exactness, which is exactly why I love the subject. I enjoyed his excitement for learning and that's why I chose him to be my mentee.

CF: What would you say was the most valuable thing in the mentor/mentee relationship for Marshall? For you?

LH: The Prison Math Project has been a fantastic opportunity for me to refresh some of my university math topics. To teach someone you need to have a strong grip on the subject yourself. It was great to push myself to teach and advise when communication is difficult.
Mentoring Marshall taught me a lot about what it's like to be incarcerated and the type of mental fortitude it takes to come out of prison a better person than you went in.
I don't really want to speak on Marshall's behalf, but I hope he learned some math and mathematical thinking that will aid him in his free life. I would also like to believe that he benefited from knowing that some random Canadian kid cared about him and his future. He has a fantastic spirit and I'm really excited to see what he does with his newfound freedom.

CF: Now that Marshall is out of prison, have you kept in touch at all? Any plans to mentor another inmate?

LH: Both of our lives have been very busy lately. We still message each other and we had a Zoom call with each other recently. It was fantastic. Marshall has started school and we'll likely be working out some sort of virtual tutoring for his upcoming math class.

At the moment, though, I don't have plans to mentor another inmate. I am stepping away to focus on my early career and studentship. However, working with the PMP has been a fantastic experience and I would encourage anyone to join.

CF: Thanks for your work with the program, Luke, and for giving Marshall the confidence to enroll in community college this fall, where he is hard at work on completing his Associate Degree. Before you go, can you tell us a bit about what you're up to these days?

LH: I'm currently on internship between my third and fourth year of software engineering. At the moment I am working as a systems software developer with a team of engineers working on network file transport acceleration. Essentially we work on a product that sends files across the internet very fast.

CF: With a schedule like yours, how were you able to fit in mentorship to an incarcerated individual?

LH: Like any other commitment, you have to find the time. I try my hardest to keep life organized with calendars and to-do lists.

CF: Any advice for those considering a mentorship through the PMP?

LH: My only advice would be to understand the importance of everything besides math. Sharing stories, advice and support can be just as helpful.

CF: Right! Good reminder! Math isn't the only thing in life—am I allowed to say that here? Thanks for taking the time to speak with us, Luke. We'll watch for you on Forbes' *30 UNDER 30*: THE MOST INFLUENTIAL YOUNG PEOPLE IN TECH. All the best in your future!

THE PRISONER'S DILEMMA:

The director of a prison offers 100 prisoners, who are numbered from 1 to 100, a last chance at freedom. A room contains 100 boxes. The director randomly puts one prisoner's number in each closed box. The prisoners enter the room, one after another. Each prisoner may open and look into 50 boxes in any order. The boxes are closed again afterwards. If, during this search, every prisoner finds his number in one of the boxes, all prisoners are pardoned and given $5000 each. If just one prisoner does not find his number, all prisoners are admonished for their stupidity and never get another chance with this. Before the first prisoner enters the room, the prisoners may discuss strategy — but may not communicate once the first prisoner enters to look in the boxes. There's no way for them to always win, but what is their best strategy?

THAT IS SO COOL!

by Amy Shell-Gellasch

Dr. Amy Shell-Gellasch is a full time lecturer at Eastern Michigan University. She earned her DA in mathematics from the University of Illinois at Chicago in 2000 and followed that with a post doctorate position at the United States Military Academy at West Point, NY. Her area of research is the History of Mathematics and its uses in teaching. She co-founded and currently chairs the History of Mathematics Special Interest Group of the MAA and is an associate editor of Convergence online journal. Currently she is the Chair of the Michigan Section of the MAA.

Amy Shell-Gellasch

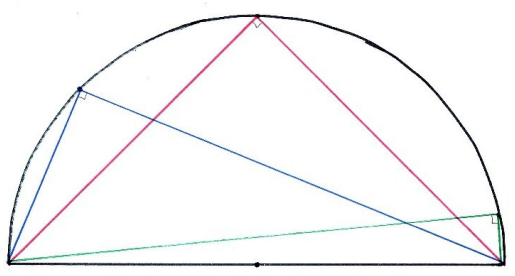
I have encountered way too many theorems over the years to count. Many theorems are useful, while others appear not to be (yet). But most are nothing to write home about. Some theorems are obvious while others defy intuitive understanding. But occasionally you run across theorems that are inspiring, beautiful, mind blowing. And some just make you say, "that is so cool!" These are the ones I like the best, especially when they occur in elementary mathematics. In this column, I and my colleagues will share some of our favorites from elementary mathematics and geometry.
Top of my list is this beauty.

Thale's Theoem:
Version 1: ANY triangle inscribed in a semi-circle is right.

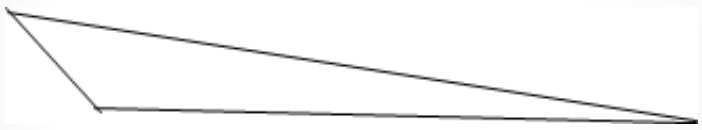
Version 2: ANY triangle inscribed in a circle that subtends the diameter is right.

In simple English, if you use the diameter of a circle as the base and any other point on the circle as the vertex of a triangle, then the angle at the vertex is a right angle (90°).

Surprisingly (to me at least) in this image, all three triangles, though very different, are all right triangles.

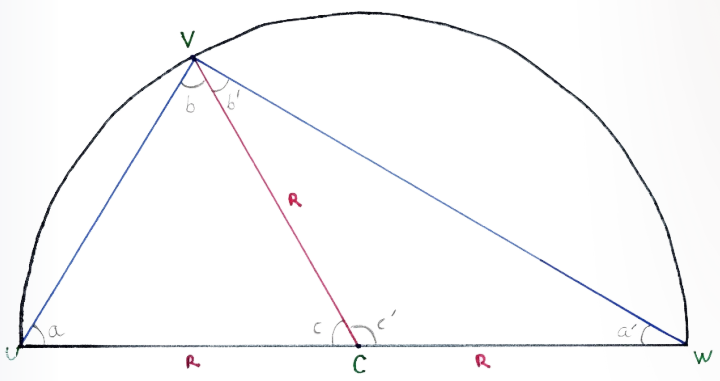


How to prove this? Think about what makes this theorem special, what facts do you have? First, it is a triangle, there are lots of useful fact about triangles.
Second, the base is the diameter of the circle. Lots of great facts about circles. But if you just used the diameter, then you can draw all kinds of triangles off the base, and they don't have to be right triangles. Like this one:



But this one does not have its vertex on the circle. So that is what is essential for this proof. We have to leverage the fact that the vertex is ON the circle. Going back to definitions is always a great place to start. The definition of a circle is the set of all points that are equidistant (the same distance) from a given point (the center). Put another way, all points on a circle are the same distance from the center, and that distance is the radius, R, half the diameter.

So let's jump in. Here is an arbitrary triangle inscribed in a circle using the diameter as a base. (It is important to use a random, or generalized drawing. If you picked a special case, such as the triangle with the vertex at the top directly above the center point, then it might have special properties that won't help you prove the theorem for ANY triangle that satisfies the criteria of the theorem.)



Points U, V, and W are the vertices of the triangle, with vertex V being the one we want to show is a right angle. To save time and make the reading easier, I will assume that the letters at each angle represent the angle measure in degrees.

Notice that I added the radius from the center to the vertex V. Given that we are working on a circle, I included what makes a circle a circle, the distance from the center to each vertex is the same, R. Also notice that we now have the original big triangle and two new smaller triangles. These two observations are the keys to the whole game! (This is how I always problem solve, I list everything I know or notice about the problem, not worrying about if I will use it or not.)

Now, what do we want to prove?
$V = 90^\circ$

Here are a whole bunch of facts.

1. Measure of angle V = b + b'

2. a = b and a' = b'
Since the two smaller triangles are both isosceles (they each have two sides of the same length, R) their base angles are equal.

So we now have that V = b + b' = a +a'

Another fact is that the angles of any triangle add to 180°. This allows us to write V in an alternative way. Writing the same thing is two ways is used in many proofs. Just like in life, looking at something from a new perspective can be very productive.

Shift your view to the big triangle.
3. $V = 180^\circ - a - a'$
$= 180^\circ - (a + a')$
$= 180^\circ - (b + b')$ from (2).

Now equate the two measures for angle V

4. V = V
$b + b' = 180^\circ - (b + b')$

Solving gives us
$2(b + b') = 180^\circ$
$b + b' = 90^\circ$

Voila! Angle V is a right angle.QED (in Latin, quod erat demonstrandum, meaning "what was to be shown")

Amy will be alternating two columns for us, *That is So Cool!* and *Math from Another Time and Place.* She says: If you would like to suggest a topic or submit a piece for either column, please email me at amy@pmathp.org

PROBLEM CHILDREN

We've all been faced with the occasional problem that breaks through our mathematical defenses. In this column, we take your "problem children" and deconstruct them in a way that we hope will aid you in your journey through mathematics.

Our first problem child comes from Jesse Waite:

Jesse: I have seen several times where an inequality is used to solve a problem or used in a proof. This is the arithmetic: geometric - mean inequality (AM-GM):

$$\sqrt{ab} \leq \frac{a+b}{2}$$

1. What does it mean?
2. How do you use it?
3. In which situations would this be helpful?

Jesse, your problem child will be "dealt with" by Christopher Havens.

Christopher: That's a good questions Jesse. During my own studies, I tend to spend hours, days (or in some cases, months!) to solve a difficult problem, but when I've tried all of the tools in my toolbox without success, the problem becomes one of my "problem children." The arithmetic mean gives the location of the number c on the number line half-way between the positions a and b. More than that, the arithmetic mean is an upper bound of the geometric mean. Perhaps that doesn't sound very helpful. But it is! Consider for a moment the problem of trying to find the square root of a number n. If we set $\sqrt{n} = \sqrt{ab}$

Where $a = g_1$ and $b = \frac{n}{g_1}$

$$\sqrt{n} = \sqrt{ab} \leq \frac{g_1 + \frac{n}{g_1}}{2} = g_2$$

Here we take g_1 to denote our initial guess as to the value of $\sqrt{n}$. When we output a value, like g_1, we simply plug it right back into the right side of the inequality to obtain increasingly closer approximations for $\sqrt{n}$.

There is no fancy footwork needed for choosing your initial guess. For example, suppose you want to find $\sqrt{2}$, but after eating a bite of something that resembles Salisbury steak, you suddenly feel disoriented after it grows tendrils and pulls itself away from your plate. Oh no! You suddenly question your reasoning behind doing math at such a time! But one thing is certain: at a time like this, it must be important.

Despite your better judgement, you guess initially that $\sqrt{2}$ must be close to 100. And why not? Setting g_1=100, we have

$$\sqrt{2} \leq \frac{100 + \frac{2}{100}}{2} = 50.01$$

Well then... That's a bit far from my better judgement. Let's use this new value as guess number 2. In other words, let g_2=50.01 so that

$$\sqrt{2} \leq \frac{50.01 + \frac{2}{50.01}}{2} \approx 25.025$$

If we just continue this way, iterating on the previous results, we can watch it creep right up, converging to a more respectable value ... safe from any of the side effects of ingesting today's cafeteria food.

$$\leq \frac{25.025+\frac{2}{25.025}}{2} \approx 12.5525$$
$$\leq \frac{12.5525+\frac{2}{12.5525}}{2} \approx 6.356$$
$$\leq \frac{6.356+\frac{2}{6.356}}{2} \approx 3.335$$
$$\leq \frac{3.335+\frac{2}{3.335}}{2} \approx 1.967$$
$$\leq \frac{1.967+\frac{2}{1.967}}{2} \approx 1.492$$
$$\leq \frac{1.492+\frac{2}{1.492}}{2} \approx 1.41624$$
$$\leq \frac{1.41624+\frac{2}{1.41624}}{2} \approx 1.414215$$

As you can see, it's converging rather fast. $\sqrt{2} \approx 1.41421356$ The AM-GM inequality assures us that our approximation will be greater or equal to the exact value. In fact, equality only occurs when a= bb.

Of course the AM-GM inequality has many other uses, but that should get you started.
Happy studies,
Jesse!

Got a Problem Child? We can help. Our contact info is on the back page of this newsletter.

BOOK REVIEW REVIEW

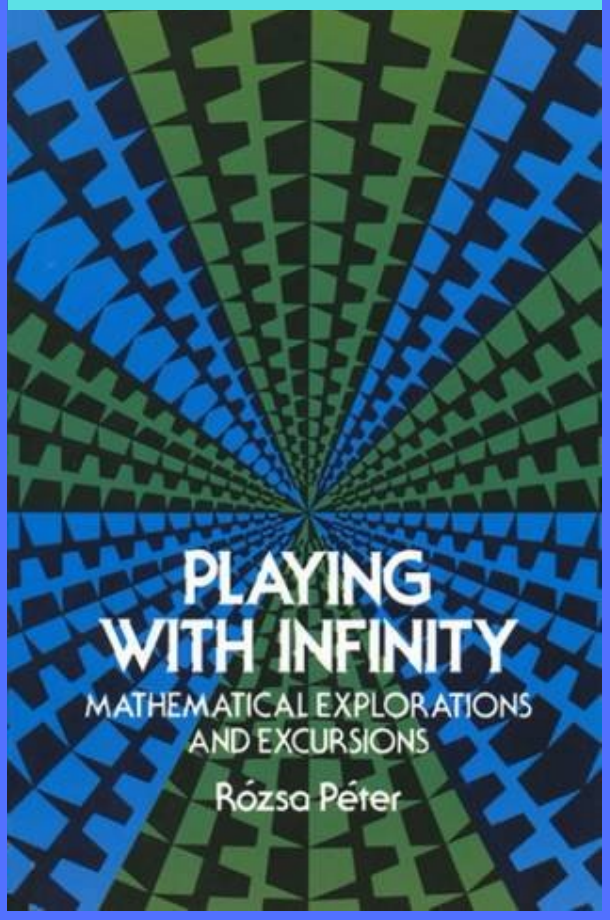
No, it's not a typo! We actually review your book reviews!

This column is dedicated to readers who would enjoy sharing their opinion of our featured book. Here's how it works: You read the book, submit a review, and if your submission is deemed most inspiring by our panel of judges, your review will be printed in a future edition of the newsletter. We'll feature a new book every six months.

Our Spring 2021 featured title was, "*Playing with Infinity: Mathematical Explorations and Excursions*," by Hungarian mathematician Rózsa Péter.
Topics in this book range from counting to mathematical logic. Each is covered with clarity and originality in Péter's work. A must-read for those beginning a study of mathematics, the arts or humanities.
The reviews are in and the judges have made their decision.

First runner-up: **Keith Deichert, FCI Loretto**
Deichert wrote an articulate and thoughtful review of *Playing with Infinity*, citing many examples from the book of the way math knowledge builds upon itself.
Well done, Keith.

And the winner of our BOOK REVIEW REVIEW is: **DANIEL POLITTE, Texas DOCJ**



Judges' comments:

This book review made me want to rush out and buy Péter's book—and Politte gives me hope I'd actually benefit from reading it. He starts with a riveting first paragraph that caught my attention right away and held it to the end. I enjoyed his use of metaphor and the way he shared his own personal experience with the book, as well as his direct appeal to potential readers. He even got all the accents on the author's name right. That's bonus points from me! – CF

I was impressed with both of these thoughtful reviews. Stylistically, they are very different, but both demonstrate a deep appreciation for Playing with Infinity. While Mr. Deichert's review provoked my curiosity about the book with his logical approach, technical descriptions, and carefully selected examples, for a math neophyte such as myself I have to say that Mr. Politte's review is more likely to make me read Playing with Infinity.His enthusiasm is infectious. His examples of the inspiration he found from the book increase the attraction of the book. I also thought the review contained insights with broad application. –DG

It is so wonderful seeing people fully jump into their learning of mathematics. And both these guys can write. If I had to choose one... which, uh, I guess that is the point ... I would have to choose Daniel's. I related to his personal style, his humour and the connections he made. Keith's read as more academic - very well written but I preferred Daniel's approach. –JL

DANIEL POLITTE'S REVIEW:

In 1943 the world was in flames, and huddled inside the country of Hungary, tucked away in its capital of Budapest, a woman, Professor Rózsa Péter, authored a book on mathematics: *Playing with Infinity*. Her book survived the German occupation of Hungary, bombings, and the rise and fall of fascism and communism. It has in its own way projected its influence into infinity. Her writing is very straightforward and well-illustrated; she illuminates important concepts without casting shadows on confusion. It is a gem of a book.

I like to think of life as a large pond or pool of water. We all create waves or ripples within it by the actions we take, the words we speak and the decisions we make. Some have bigger splashes than others, but the impact sends its wave out throughout time, where it combines with others, and they carry onward toward infinity. This year, 2021, the ripples and waves of Rózsa Péter's book inspired me and gave me the confidence to further my own mathematical education.

Playing with Infinity requires very little prior knowledge of math. In fact, the book literally begins with a chapter titled, 'Playing with Fingers' and gradually progresses to more involved (and interesting) topics. If mathematics has always been a challenge for you, or you think you'll never "get" it, this book will help you out. The beginning is well written and the concepts are explained in ways easily visualized. Subsequent chapters build on the ones before, kind of like stacking firewood or Lego bricks. Eventually I found myself understanding concepts like Integrals and complex numbers. These subjects were always confusing to me, and a lesser author would fail in explaining them where Professor Péter succeeds.

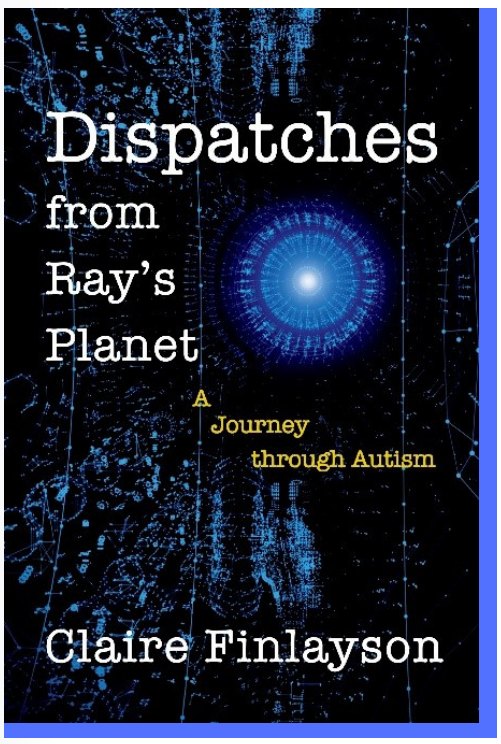
There are a few things that are helpful to know about this book before beginning to read it. Firstly, those that have always balked at formulas will be relieved that there are relatively few here. When they are included, the formula is revealed in a sort of process—a bit at a time—till the reasons it exists are firmly understood. Then, instead of seeing a page plastered with arcane scribbles, you see the logic behind the way it
works and why.

However, a second thing to know is that this book really should not be skimmed, and chapters should not be skipped. Reading a book on mathematics requires a bit of focus—maybe a bit more than reading the latest spy-techno-fantasy thriller. To make what you are learning really "stick," I advocate active reading. What is that? Essentially it is reading with a pen, pencil, highlighter or coloured pencils, underlining what seems important to you. My copy of *Playing with Infinity* now has notes in the margins and bits/pieces/whole paragraphs underlined in different colours. All of this is a sort of "hack" or "trick" that helps your mind recall what you've read. Active reading isn't for everyone, but I heartily suggest giving it a try.

Professor Péter uses wonderful examples to explain a large number of the more important concepts in the realm of math. A very good case is how she handles introducing the reader to complex numbers that are partially real and partially imaginary. She uses her deft grasp of all this to show how circular functions and power functions connect, how complex numbers get involved, and she shows step by step how it actually makes sense. Or how about this: she illustrates that cringeworthy titled “hyperbolas” and “parabolas” are just slices of a cone!
Math, at the end of all its confusing-seeming concepts, is really just the language of logic. It is a way that we can take a really hard-to-articulate concept and communicate it to another with 100% accuracy, and with little to no mix-ups. If we were all to sit down and write out how to make a PBJ sandwich, something I presume we all know, there would be many different ways. In math, when we add 2+2, it always equals 4—no ifs, ands or buts. Furthermore, 2+2 is always 4 in every language. It doesn’t matter if you speak English, Farsi, Mandarin or Martian. It is easy to gloss over this fact and miss how absolutely amazing this is.

I really hope that if you are reading this review, you read *Playing with Infinity*. The notion that you are either a math person or not is patently false. A little bit of your time spent on this book should give you the confidence it gave me. You can learn this stuff; it is useful, and education is something that will never leave you. Personally, I am really excited to see what the PMP has planned and to start working with a mentor. A lot of concepts that used to confuse me now finally make sense. (I’m looking at you, Mr. Integral!)
Like with most things in life, you’re going to get out what you put in. I firmly believe that if you read this book and work with a mentor, your math skills cannot help but improve. Perhaps it might even spawn some future mathematicians? You owe it to yourself to invest in yourself, and this is a great way to do just that.
Thank you Professor Rózsa Péter for making a ripple in time 78 years ago that travelled all this way to inspire me.
I hope she inspires you, too.
Daniel Politte

In the next edition of the PMP newsletter we will be featuring the winning review for Claire Finlayson's "*Dispatches from Ray's Planet: A Journey through Autism.*" This compelling memoir reveals how the author discovered some surprising truths about her proudly eccentric brother. Communicating with Ray in writing revealed the man within and upended much of what she thought she knew about him,about neurodiversity--and even about herself.



Although not a math text, *Dispatches* does showcase Ray’s patience and dedication as a math tutor and his profound reverence for mathematics, “the language in which God wrote the universe.” Christopher Havens says the book “embodies empathy and inclusivity.” It has become a springboard to Ray’s involvement with the PMP – and Claire’s, too, as editor of this newsletter.
Here’s how the contest works:

Reviews must be no longer than 1,000 words and all submissions for the review of "Dispatches from Ray's Planet" need to be submitted by February 1, 2022. The winning review will be published in our May edition of the newsletter.
To submit electronically, send your review to: claire@finlaysons.ca

Mail paper submissions to:
Prison Mathematics Project
Attn: Book Review Submission
10810 N. Tatum Blvd, Suite 102-998
Phoenix, AZ 85028

Going forward, each new book will be introduced and reviews for the previous book featured in our spring and fall editions of the newsletter. Reviews will need to be submitted by February and August 1st, respectively. If you can't obtain a copy of the featured book on your own, we'll send you a copy while supplies last. Simply write and let us know about your circumstances.

A MISCREANT'S MISCELLANY

By Christopher Havens

Meaning in Mathematics -
With Amit Sahai

Christopher Havens

Amit Sahai

CH: Greetings, readers! Today we get to explore the meaning and beauty of mathematics with one of my dearest friends, Amit Sahai.

Amit, why don't we begin with you telling us a little aboutyourself.

AS: Hi Christopher!
Sure, I'm a mathematician – I prove theorems for a living. I work in the field of theoretical computer science, so the theorems I prove are typically connected to understanding what computers can and cannot do. This examination of the boundary of the possible and the impossible is what most draws me into mathematics. But I'm jumping ahead! I'm a professor of computer science at UCLA, and I love teachingand working with my students,especially in collaboration on beautiful research questions.

CH: One of the things I really appreciate is that your way of socializing is by engaging people through mathematics and research. I call this social productivity, where our interactions not only build these really incredible bonds, but they also hold value within the community through collaborative work.

Don't you find the social aspect of mathematics powerful beyond words? For example, when you engage in research with another human being, there is a distinct type of exchange where you share days, sometimes months, working inside of another person's imagination. You get to journey down somebody else's rabbit hole. You're following the thread of their thoughts in an intimate way, and vice versa. There is vulnerability, where your strengths and weaknesses are painted in detail for the other person to see. But that's part of the beauty of it! Here is where you can really identify a kindred spirit.

But I'm talking too much! Amit, can you speak about the joy obtained through shared exploration? Can you describe any particularly meaningful instances?

AS: Wow, honestly there are too many wonderful collaborations to choose from. Let me tell you a little about one of my most recent —though it is such a long story itis hard to summarize. How do you describe any important relationship in just a few words? One of the greatest joys of being a professor at a research university is that you get to know wonderful doctoral students, and you see them develop as researchers. I have a student named Aayush who just defended his thesis a few days ago. Over the past few years, our collaboration has grown. Now we call each other at odd hours with new ideas while they are still in an inchoate form, and we develop them together. You cannot guess how many breakthroughs we have had, where it started with a conversation like this:

A: ”I thought of something but it doesn’t seem to work.”
B: ”Tell me anyway.”
It takes a wonderful friendship and trust to build collaborations like that. Of course, many – indeed the majority – of such ideas don’t ever amount to anything. So as you mentioned, there is a vulnerability and trust that must exist for such conversations to be possible. It is sad to think of how many scientific advances humanity may have missed out on just because someone was too afraid of looking like an idiot to share their ideas before those ideas could fully form through a collaborative effort.

CH: Certainly. And these meaningful collaborations can also be sources of awe and humility. For example,I remember a collaboration with some really wonderful mathematicians in Italy. One of them was named Stefano. Boy, did this guy have style! In one of our researches, I was attempting to solve a really difficult problem. The time had come to turn coffee into theorems! Pages were scattered out in front of me as I began constructing a proof. I moved on to defining concepts and making lemmas that would help me achieve my goal. Structure began to emerge. Hours turned into days … or weeks … I couldn’t tell which. Static popped in the air—or maybe it was just thoughts, but finally, when all was said and done, I had upwards of five wonderful pages of meticulously crafted thought. The proof. I showed Stefano, and within a day or two he had sent me his version. The moment I saw it I was in awe of his work.

Stefano’s proof was one single line of math. He presented it in a way that seemed obvious. It was mathematical beauty—a proof "for the book.” He didn’t share his proof to brag or to make me feel any particular way about it. Nope. He shared it because when you’re collaborating on a research,you want the ideas to be revealing and elegant. Plus, you want your friends to know how to adjust their own practices for improvement. And maybe part of it was his way of saying politely, ”Pehaps we should go with something a little more intuitive and concise.” It was a lesson in humility for me, which I gladly accepted.

That was such a wonderful plethora of lessons all bundled into one. It’s not always easy to accept that our ideas are failures—though the wonderful thing about mathematics, especially in collaborative efforts and research, is that almost always a failure can be interpreted as a discovery that something doesn’t work, and many times, we find within those failures the seeds for new mathematics. Amit, while I have only just gotten my feet wet, you’ve lived a life of research. What can you say about awe and humility?

AS: Your story reminds me of some of the more nontrivial lessons I’ve learned over the years. Let me be clear that I’m speaking broadly, and this may not apply to the experience you described.

We are all drawn to mathematical beauty, and rightly so. And it is easy to appreciate the ethereal beauty of a highly refined, succinct proof.And we should certainly always strive to find that beauty, as it gets us closer to the ”core”of what is needed to establish a theorem. But there is another kind of imperfect, more human beauty often to be found in the first proof we obtain, especially for a result that is hard fought. Almost surely, this proof is filled with extraneous ideas and unnecessary meanderings. But its beauty comes from the fact that it is usually rich in intuition and guidance. The extraneous ideas often point to other fascinating vistas that need exploration. The path that was followed shows us how mere human thought can allow us to explore deep and abstract mathematical truth.

When I started in research, I was so dazzled by elegant short proofs ”from the book” that I looked down my nose at the messier proofs. This was a mistake. Almost all the most significant results I’ve been fortunate enough to help discover over the years have been obtained by following messy routes. Of course, cleaning up and strengthening those proofs is really exciting, and definitely very important – and often a source of great joy. But that first messy proof,hard earned, is beautiful. I feel lucky to have learned this lesson early in my life of research.

CH: I’ve never thought of it like that…
I’m going to shift gears a little, Amit. We’ve been exploring the meaning that comes from our engaging in mathematics, but what about how this universe seems to be written in mathematics?

AS: Isn’t it amazing? It is one of the most basic things that we take for granted.Why is it that this universe seems to work according to laws that can be written in mathematics, that seem to obey all the logical rules of mathematics? And yes, most likely we humans study this thing called mathematics precisely because it seems to describe how the universe works. But that doesn’t take away any of the wonder of it. Whatever that creative entity was that caused this universe to exist, the one thing we know for sure is that it definitely, positively, operated mathematically. If you believe in God, you have to agree that God apparently loved mathematics enough to base the entire universe on it. Or even if you don’t believe in God, the fact that the universe is apparently built upon mathematics certainly strongly suggests that mathematics has an inherent pre-eminence.

CH: My belief drifts to the latter, but I will say this: I have this feeling of connection to something much bigger than my heart can contain, and I know this feeling to be causally related to mathematics. What this means, I can’t say. I used to want to believe that God *is* mathematics because something must always come first. So if I let myself imagine an “egg” to the chicken in the story of all things, then I feel that mathematics is the only thing that can precede all things. But I have come to accept that these are questions too big for my puny little grape of a brain.

The truth is that I don’t know if I subconsciously study mathematics because it seems to describe how the universe works. But as I mentioned above, it does something to me. My heart seems to fill to its maximum capacity with... shoot, I don’t know the proper name for it. Love? Joy? Wonder or awe?

It’s hard to explain. But anyone who knows a little about my story has probably heard the extent to which mathematics has permeated my life and caused a transformation that no words can truly describe.

Mathematics, in this sense, has saved my life. So when I do mathematics, I am in an ultimate and overflowing state of love. *Ugh!* I wish I could describe it without sounding like a complete raving lunatic. But it’s a real thing, and hell, maybe this *does* speak to some deeper universal truth. One thing is certain: there is more to mathematics than just mathematics.

AS: Well said. I know what you mean, and when we take ego out of it, mathematics is a transcendent thing to me, too. And when I wrote about why ”*we*” study mathematics – I actually meant to wonder about why *humanity* stumbled upon mathematics. I think it is reasonable to conjecture that the mathematical underpinnings of the universe may have had something to do with it. But at the same time, why did humanity stumble upon poetry or art? When I first fell in love with mathematics myself, I don’t think that it had anything to do with explaining the universe - though I can’t say I actually remember for sure. There was just something inherently beautiful about mathematics that drew me to it.

You talked about your ”little grape of a brain,” Christopher, and I think that, too, is a thought that any mathematical researchers who are honest with themselves can share. The vast majesty of mathematics, filled with unknowns, reflects and indeed dwarfs the vastness of the universe and the mysteries contained within it. I’ve written elsewhere about Gödel’s incompleteness theorems and the inherent nature of our lack of a full understanding of mathematics. But even at the basic experiential level, every researcher comes across far more fascinating problems that they cannot solve than problems that they *can* solve. One can’t help but sit in awe of mathematics.

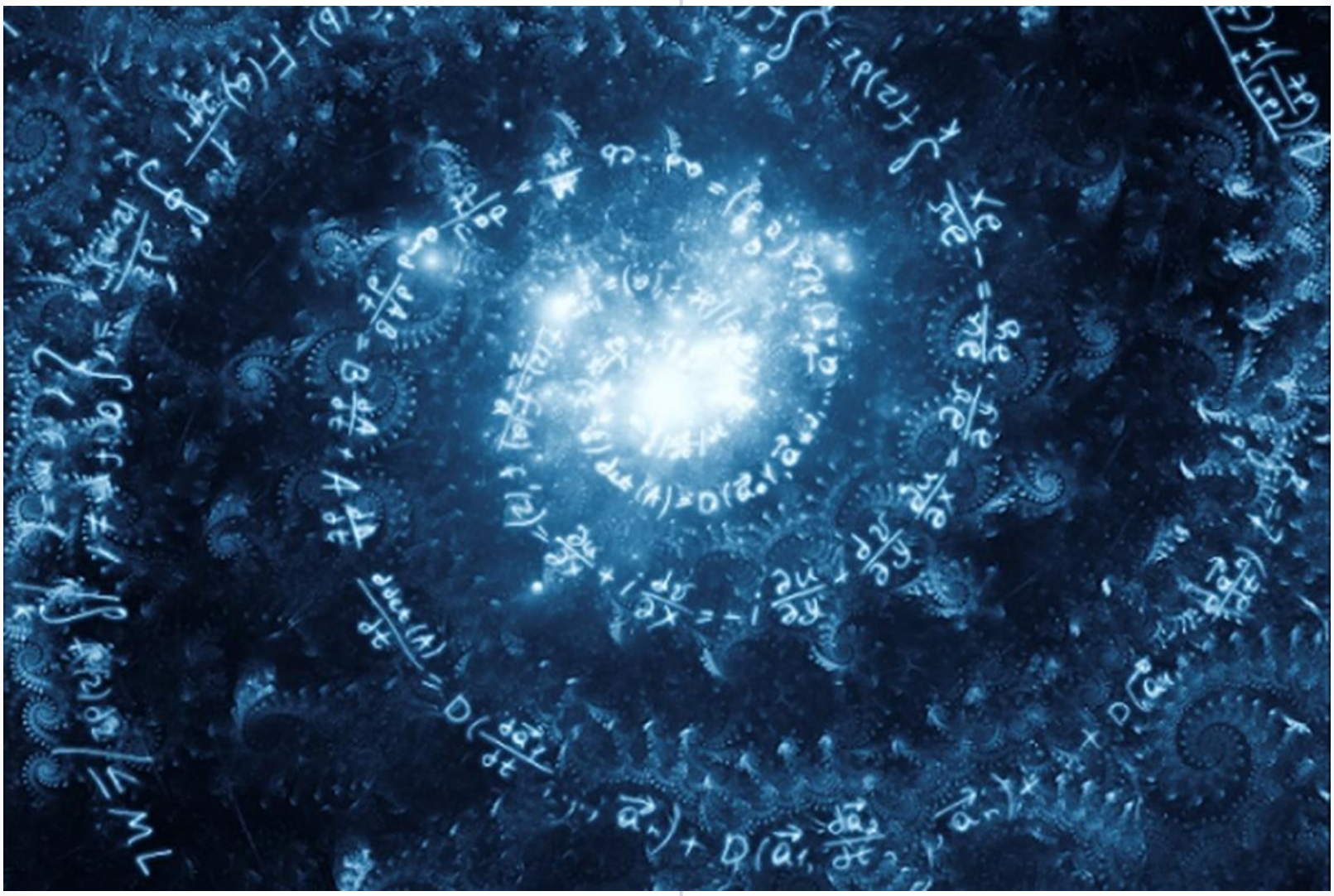
If anything, I’d say that the daily ”grind”of wrestling with mathematics can sometimes make us forget the transcendent nature of our object of study. I’d say this is similar to how parents can sometimes forget what incredible miracles and blessings their children are. But then you look into their eyes and remember. It is important to do the same with mathematics – and then immediately we remember how lucky we are to be able to study mathematics!

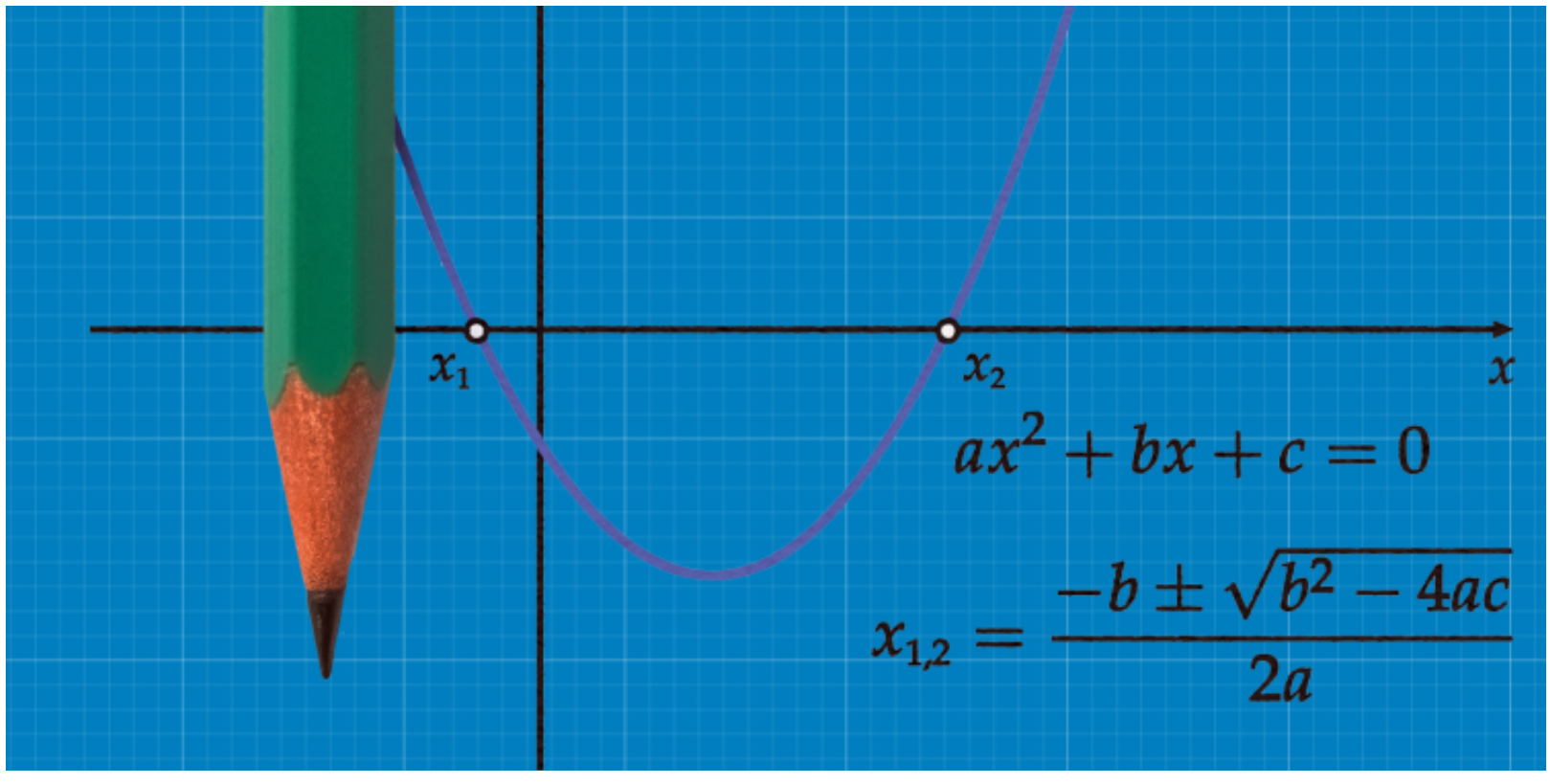
CH: Absolutely! I think it’s important to explore meaningful ways to bring out the beauty of mathematics, so I’d like to present a challenge to each of our readers:

The challenge involves a collaboration between you and a friend or mentor. Together, write a piece on mathematics—any math you want, whether it be art, history, philosophy, fiction or a research. But collaborate! Send your finished project to Christopher at the Prison Mathematics Project and your submission will be published on humanme.org for others to enjoy!
Here’s the catch: it must be clean and good-natured.

AS: This challenge is a wonderful idea! Nothing like combining mathematics and friendship. Christopher, maybe you and I can write a submission together?
Great to talk with you!

CH: Bring it on! Amit, it was an absolute pleasure, as always!!





CLOSING NOTES TO OUR PARTICIPANTS:

We have made some exciting progress recently in getting access to additional resources for you.

The Math Association of America has kindly offered to provide free subscriptions to *Math Horizons* magazine for all of our participants. Many of you will already have received your first copy. Please let us know if you did not receive a copy or if you would prefer not to receive the subscription.

We have also recently formed partnerships with a few math book publishers who are generously offering to donate math books to us throughout the year. This will be a big help, given that math books can be a huge cost for many.

Beyond books, I know many of you were excited about the algebra material that Ron Bannon is working on. Sorry that it has taken a while, but the great news is that a publisher has agreed to publish this for us for free. Because it is still a work in progress, the process will be that we'll send out the first few chapters now. Once you are ready for further material, just write to us to request and we'll send out the additional chapters. We can also provide electronic versions of the chapters to your mentor, so they can answer any questions you may have.

As many of you know, everyone working on The Prison Math Project is an unpaid volunteer, generously donating their time to help. We will soon be embarking on our first-ever fundraising campaign, in order to keep providing value to you all, including paying for things like this newsletter; printing and mailing costs of correspondence, etc. Unlike some organizations, the PMP does not charge for participation in the program; however, I would like to extend our appreciation to a number of participants who voluntarily made donations to us, including Jeffery and Paul. We have also had a few mentors who have gone beyond just donating their time to also make financial donations to our project.

As usual, please write to us at the address on the back page if you experience any problems, such as not receiving a letter from your mentor for many months or anything like that.

Wishing you all the best until next time.

-Jack
(acting Executive Director at the Prison Math Project)

PMP

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